CLAIMS

What is claimed is:

1. A method of controlling a material handling system that lifts a load, the system including a motor, a brake and a drive, the method comprising:

storing a model of the motor in the drive;

generating a signal in the drive, the signal having a voltage and a frequency;

providing the signal to the motor;

sensing a current value of the signal;

providing a modeled value based in part on the sensed current value;

comparing an actual value to the modeled value to determine whether the load is stable; and

generating an output that sets the brake when the load is potentially unstable.

2. A method as set forth in claim 1 wherein the method further comprises entering a direction and speed into the drive, and generating the signal based in part on the entered direction and speed.

3. A method as set forth in claim 1 wherein the storing of the model includes

performing at least one test on the motor,

recording data during the test, and

creating the model based on the recorded data.

4. A method as set forth in claim 3 wherein the performing at least one test on the motor includes performing a static parameterization test on the motor.

5. A method as set forth in claim 3 wherein the performing at least one test on the motor includes performing a dynamic parameterization test on the motor.

6. A method as set forth in claim 3 wherein the performing at least one test on the motor includes performing a stepped-value parameterization test on the motor.

7. A method as set forth in claim 1 wherein comparing the actual value to the modeled value includes

obtaining a difference value relating to the difference between the actual value and the modeled value, and

comparing the difference value with a deviation amount.

8. A method as set forth in claim 7 wherein obtaining the difference value includes filtering the difference value.

9. A method as set forth in claim 7 wherein generating the output that sets the brake when the load is potentially unstable includes

incrementing a timer when the difference value is greater than the deviation amount, and

generating the output when the timer is greater than a time period.

10. A method as set forth in claim 7 wherein generating the output that sets the brake when the load is potentially unstable includes generating the output when the difference value is greater than a deviation amount.

11. A method of controlling a material handling system that lifts a load, the method comprising:

providing a material handling system having a motor, a brake, an inverter, and a model of the motor;

generating a signal in the inverter;

providing the signal to the motor;

sensing a current of the signal, the sensing occurring within the drive;

determining a modeled torque producing current based in part on the sensed current;

determining a modeled motor speed based in part on the sensed current;

determining an applied torque producing current;

determining an actual motor speed;

calculating a first difference value between the applied torque producing current and the modeled torque producing current;

comparing the first difference value with a first deviation amount;

setting the brake when the first difference value is greater than the first deviation amount;

calculating a second difference between the actual motor speed and the modeled motor speed;

comparing the second difference with a second deviation amount; and

setting the brake when the second difference is greater than the second deviation amount.

12. A method as set forth in claim 11 wherein calculating the first difference value includes filtering the first difference value.

13. A method as set forth in claim 11 wherein calculating the second difference value includes filtering the second difference value.

14. A method as set forth in claim 11 wherein determining an applied torque producing current includes determining the applied torque producing current based in part on the sensed current, and wherein determining an actual motor speed includes determining the actual motor speed based in part on the sensed current.

15. A method as set forth in claim 14 wherein determining the modeled torque producing current value includes

determining a modeled current based in part on the sensed current,

determining a magnetizing current based in part on the sensed current, and

determining the difference between the modeled current and the magnetizing current.

16. A method as set forth in claim 15 wherein determining the applied torque producing current includes determining the difference between the sensed current and the magnetizing current.

17. A method as set forth in claim 11 and further comprising:

comparing the second difference value with a third deviation amount;

incrementing a counter when the second difference value is greater than the third deviation amount; and

setting the brake when the counter is equal to a time period.

18. A method of sensing an unstable state of a material handling system that lifts a load, the system including a motor, a brake, and a drive, the method comprising:

providing a material handling system having a motor, a brake, an inverter, and a model of the motor;

generating a signal in the inverter, the signal including a voltage and a frequency;

providing the signal to the motor;

sensing a current of the signal, the sensing occurring within the drive;

when one of the voltage and the frequency is less than a first percentage of a maximum voltage and a maximum frequency, respectively,

determining a modeled current based in part on the sensed current,

determining a magnetizing current based in part on the sensed current,

determining the difference between the modeled current and the magnetizing current,

determining the difference between the sensed current and the magnetizing current,

calculating a first difference value between the applied torque producing current and the modeled torque producing current;

comparing the first difference value with a first deviation amount;

setting the brake when the first difference value is greater than the first deviation amount;

when one of the voltage and the frequency is less than a second percentage of the maximum voltage and the maximum frequency, respectively,

determining a modeled motor speed based in part on the sensed current;

determining an actual motor speed based in part on the sensed current;

calculating a second difference value between the actual motor speed and the modeled motor speed;

comparing the second difference value with a second deviation amount; and

setting the brake when the second difference value is greater than the second deviation amount.

19. A method as set forth in claim 18 and further comprising when one of the voltage and the frequency is less than a third percentage of the maximum voltage and the maximum frequency, respectively,

comparing the second difference value with a third deviation amount;

incrementing a counter when the second difference value is greater than the third deviation amount; and

setting the brake when the counter is equal to a time period.

20. A method as set forth in claim 19 wherein the first percentage is fifty percent, the second percentage is fifteen percent, and the third percentage is thirteen percent.

21. A material handling system comprising:

a lifting apparatus being connectable to a load, the lifting apparatus including a brake, and a motor;

an inverter electrically connected to the motor and being operable to generate an inverter signal that drives the motor;

a current sensor being operable to sense a current of the inverter signal and to generate a current signal having a relationship to the sensed current; and

a controller being operable to

receive the current signal,

determine a modeled value of the motor based in part on the current signal,

compare an actual value to the modeled value for determining whether the load is stable, and

generate an output that sets the brake when the load is potentially unstable.

22. A system as set forth in claim 21 wherein the system further comprises a memory, wherein the memory stores a model of the motor, and wherein the controller is operable to determine a modeled value by being further operable to access the model stored in memory.

23. A system as set forth in claim 21 wherein the controller is operable to compare the actual value to the modeled value by being further operable to

obtain a difference value relating to the difference between the actual value and the modeled value, and

compare the difference value with a deviation amount amount.

24. A system as set forth in claim 21 wherein the controller is operable to obtain a difference value by being further operable to filter the difference value.

25. A system as set forth in claim 23 wherein the controller is operable to generate the output that sets the brake by being further operable to

increment a timer when the difference value is greater than the deviation amount, and

generate the output when the timer is equal to a time period.

26. A system as set forth in claim 23 wherein the controller is operable to generate the output that sets the brake by being further operable to generate the output when the filtered value is greater than the deviation amount.

27. A system as set forth in claim 21 wherein the modeled value is a modeled torque producing current, and wherein the actual value is an applied torque producing current.

28. A system as set forth in claim 27 wherein the controller is operable to determine the modeled torque producing current by being further operable to

determine a modeled current based in part on the current signal,

determine a magnetizing current based in part on the current signal, and

calculate the modeled torque producing current by subtracting the magnetizing current from the modeled current.

29. A system as set forth in claim 27 wherein the inverter signal has a voltage, wherein the controller is operable to determine the modeled torque producing current by being further operable to

determine a modeled current based in part on the current signal and the voltage,

determine a magnetizing current based in part on the current signal and the voltage, and

calculating the modeled torque producing current by subtracting the magnetizing current from the modeled current.

30. A system as set forth in claim 28 wherein the controller is further operable to determine the applied torque producing current based in part on the current signal.

31. A system as set forth in claim 30 wherein the controller is operable to determine the applied torque producing current by being further operable to

calculating the applied torque producing current by subtracting the magnetizing current from the current signal.

32. A system as set forth in claim 31 wherein the controller is operable to compare the applied torque producing current to the modeled torque producing current by being further operable to

obtain a difference value relating to the difference between the applied torque producing current value and the modeled torque producing current value, and

compare the difference value with the deviation amount.

33. A system as set forth in claim 31 wherein the controller is operable to obtain a difference value by being further operable to filter the difference value.

34. A system as set forth in claim 32 wherein the controller is operable to generate the output that sets the brake by being further operable to

increment a timer when the difference value is greater than the deviation amount, and

generate the output when the timer is equal to a time period.

35. A system as set forth in claim 32 wherein the controller is operable to generate the output that sets the brake by being further operable to generate the output when the difference value is greater than the deviation amount.

36. A system as set forth in claim 21 wherein the modeled value is a modeled motor speed, and wherein the actual value is an actual motor speed.

37. A system as set forth in claim 36 wherein the actual motor speed is based in part on the current signal.

38. A system as set forth in claim 37 wherein the inverter signal has a voltage and a frequency, and wherein the modeled motor speed is based in part on the current signal, the sensed voltage and the sensed frequency.

39. A system as set forth in claim 36 wherein the controller is operable to compare the actual motor speed to the modeled motor speed by being further operable to

obtain a difference value relating to the difference between the actual motor speed and the modeled motor speed; and

compare the difference value with a deviation amount.

40. A system as set forth in claim 36 wherein the controller is operable to obtain the difference value by being further operable to filter the difference value.

41. A system as set forth in claim 39 wherein the controller is operable to generate the output that sets the brake by being further operable to

increment a timer difference value is greater than the deviation amount, and

generate the output when the timer is equal to a time period.

42. A system as set forth in claim 41 wherein the controller is operable to generate the output that sets the brake by being further operable to generate the output when the difference value is greater than the deviation amount.

43. A system as set forth in claim 21 wherein the current sensor is a hall-effect sensor.

44. A system as set forth in claim 21 wherein the system further comprises a drive having a housing, and wherein the inverter, current sensor and controller are mounted within the housing.